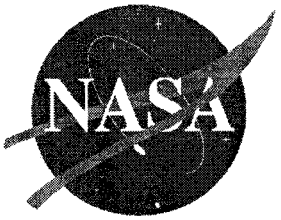

NOT MEASUREMENT SENSITIVE

National Aeronautics and Space Administration

MSAD-PLAN-0002
September 18, 2000

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

PROJECT PLAN

FOR

TOWARD UNDERSTANDING PORE FORMATION AND MOBILITY DURING CONTROLLED DIRECTIONAL SOLIDIFICATION IN A MICROGRAVITY ENVIRONMENT (PFM)

MATERIALS SCIENCE PROGRAM OFFICE

Approved for Public Release; Distribution is Unlimited

Enclosure 3

MSAD-PLAN-0002
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FOR
TOWARD UNDERSTANDING PORE FORMATION AND MOBILITY DURING CONTROLLED DIRECTIONAL SOLIDIFICATION IN A MICROGRAVITY ENVIRONMENT (PFM)

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Release Date:	**Marshall Space Flight Center** **SPECIFICATION/DOCUMENT** **CHANGE INSTRUCTION**	Page__1_of__1_

Specification/Document Number: MSAD-PLAN-0002			Copy Number:
Change Number/Date	SCN/DCN Number/Date	CCBD Number/Date	Replacement Page Instructions
–			Baseline Release

MSFC Form 4140 (Rev. September 1990) **NOTE: After revising the document, file this sheet in document preceding Table of Contents.** Informed 2.6.3

TOWARD UNDERSTANDING PORE FORMATION AND MOBILITY DURING CONTROLLED DIRECTIONAL SOLIDIFICATION IN A MICROGRAVITY ENVIRONMENT (PFM)

TABLE OF CONTENTS

PARAGRAPH **PAGE**

LIST OF FIGURES

LIST OF TABLES

1.0 SCOPE

This project plan applies to Dr. Richard N. Grugel's International Space Station (ISS) Microgravity Science Glovebox (MSG) Investigation entitled "Toward Understanding Pore Formation and Mobility During Controlled Directional Solidification In A Microgravity Environment" (PFM). This investigation was approved under the 1996 solicitation for Materials Science Glovebox Investigations and has been identified for possible flight on the ISS MSG First Utilization Flight (UF-1). The currently scheduled launch date for UF-1 is October 4, 2001 on the U.S. Orbiter STS-106. Due to constraints imposed on the project in the 1996 Solicitation for Glovebox Proposals (size, purpose, cost, risk) this Project Plan (PP) will be specifically tailored, in accordance with NPG 7120.5, to include the Safety and Mission Assurance (S&MA) Plan, Quality Assurance (QA) Plan, Risk Management Plan and Configuration Management Plan (CMP). PFM is classified as a subrack payload per SSP 50431, Space Station Program Requirements for Payloads.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this plan:

ANSI/ASQC Q9001-1994	Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Servicing
g-LIMIT-DOC-0001	Design Definition Document for Glovebox Integrated Microgravity Isolation Technology (g-LIMIT) Characterization Test
KHB 1700.7	Space Shuttle Payload Ground Safety Handbook
MPG 6410.1	Handling, Storage, Packaging, Preservation, and Delivery (H.S.P.P.&D.)
MPG 8715.1	Marshall Safety, Health, and Environmental (SHE) Program
MSFC-ICD-3085	Microgravity Science Glovebox (MSG) Interface Control Document for Toward Understanding Pore Formation and Mobility During Controlled Directional Solidification In A Microgravity Environment (PFM)
MSFC-MNL-1951	MSFC Change Processing Tracking and Accounting System User Guide
MSFC-PLAN-2997	Microgravity Materials Science Program Discipline

	Change Control Plan
MSFC-PLAN-3052	Microgravity Science Glovebox (MSG) Investigation Integration Plan
MSFC-RQMT-2888	Microgravity Science Glovebox (MSG) Investigation Interface Requirements Document
MSFC-STD-2594	Threaded Fastener Management and Control Practices
MSG-RIBRE-RQ-0001	Microgravity Science Glovebox (MSG) Payload Accommodations Handbook
MWI 1280.5	MSFC ALERT Processing
MWI 7120.3	Program/Project Data System (PDS)
MWI 7120.6	Program/Project Risk Management
MWI 8040.2	Configuration Control, MSFC Programs/Projects
NPD 8730.2	NASA Parts Policy
NPG 7120.5	NASA Program and Project Management Processes and Requirements
NSTS 13830	Implementation Procedure for NSTS Payloads System Safety Requirements
NSTS 1700.7	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 1700.7, ISS Addendum	Safety Policy and Requirements for Payloads Using the ISS (ISS Addendum)
SD40-OWI-001	MSFC Microgravity Science and Applications Department Management Process
SD42-RQMT-0002	System Requirements for Toward Understanding Pore Formation and Mobility During Controlled Directional Solidification in a Microgravity Envinroment (PFM) for Hardware and Software
SD46-SRS-PFM	Science Requirement Sheets (SRS) for Toward Understanding Pore Formation and Mobility During

3.0 ABBREVIATIONS/ACRONYMS

ADP	Acceptance Data Package
ALERT	Acute Launch Emergency Restraint Tip
AR	Acceptance Review
CCB	Configuration Control Board
CDMG	Configuration and Data Management Group
CM	Configuration Management
CMP	Configuration Management Plan
COC	Certificate of Compliance
COTR	Contracting Officer's Technical Representative
COTS	Commercial Off-The-Shelf
CPTAS	Change Processing Tracking and Accounting System
CS	Civil Servant
CWC	Collaborative Work Commitment
DAQPad	Data Acquisition Pad
DCCB	Discipline Change Control Board
DMP	Data Management Plan
EEE	Electrical, Electronic and Electromechanical
FDS	Fire Detection and Suppression
FRR	Flight Readiness Review
FSE	Flight Support Equipement
FTE	Full Time Equivalent
FY	Fiscal Year
GFE	Government Furnished Equipment
GI	Glovebox Investigator
g-LIMIT	Glovebox Integrated Microgravity Isolation Technology
GSE	Ground Support Equipment
HEDS	Human Exploration and Development of Space
ICD	Interface Control Document
IDR	Investigation Design Review
IICDR	Investigation Integration Critical Design Review
IIPDR	Investigation Integration Preliminary Design Review
IIRR	Investigation Integration Readiness Review
IIT	Investigation Integration Team
IR	Inspection Record
IRD	Interface Requirements Document
IRS	Investigation Requirement Sheets
ISS	International Space Station

JSC	Johnson Space Center
KSC	Kennedy Space Center
MIUL	Material Item Usage List
MLC	MSG Laptop Computer
MRB	Material Review Board
MRD	Microgravity Research Division
MRPO	Microgravity Research Program Office
MSAD	Microgravity Science and Applications Department
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MUA	Material Usage Agreement
NASA	National Aeronautics and Space Administration
OWI	Organizational Work Instruction
PCB	Project Control Board
PCM	Process Control Module
PDL	Payload Data Library
PDS	Program/Project Data System
PFM	Toward Understanding Pore Formation and Mobility During Controlled Directional Solidification in a Microgravity Environment
PM	Project Manager
PP	Project Plan
PS	Project Scientist
PSR	Pre-Ship Review
PSRRB	Payload Safety Readiness Review Board
QA	Quality Assurance
QMS	Quality Management System
RID	Review Item Discrepancy
S&MA	Safety and Mission Assurance
SCDP	Safety Compliance Data Package
SCN	Succinonitrile
SE	Systems Engineer
SOW	Statement of Work
SRS	Science Requirement Sheets
SUBSA	Solidification Using A Baffle In Sealed Ampoules
TMI	Tec-Masters Incorporated
TRR	Test Readiness Review
TSC	Telescience Center
UF-1	First Utilization Flight
VRSD	Verification Requirements and Specification Document

4.0 OBJECTIVES

The purpose of the PFM investigation is to test the performance of directional solidification in microgravity, to improve the production of uniform composites and to promote the understanding of detrimental porosity and mobility during controlled directional processing. Directional solidification

experiments will be conducted in the microgravity environment with succinonitrile (SCN) contained inside of transparent tubes with the intent of observing porosity formation and its movement. Methods to minimize porosity and its influence will also be examined. Experimental variables to be investigated include, but are not limited to, bubble size, bubble number, imposed temperature gradient, material properties, and the effect of applying vibration to the system.

The minimum success criteria for PFM would be observing and understanding why pore formation occurred.

Complete success would be achieved by developing a means to eliminate the evolved porosity or at least, to minimize its influence. Furthermore, observation of bubble (pore) interactions in the bulk liquid and at the solid/liquid interface would be sufficient to compare with, or amend, current theory.

Figure 1 shows the relationship between the NASA Agency Mission and the PFM investigation.

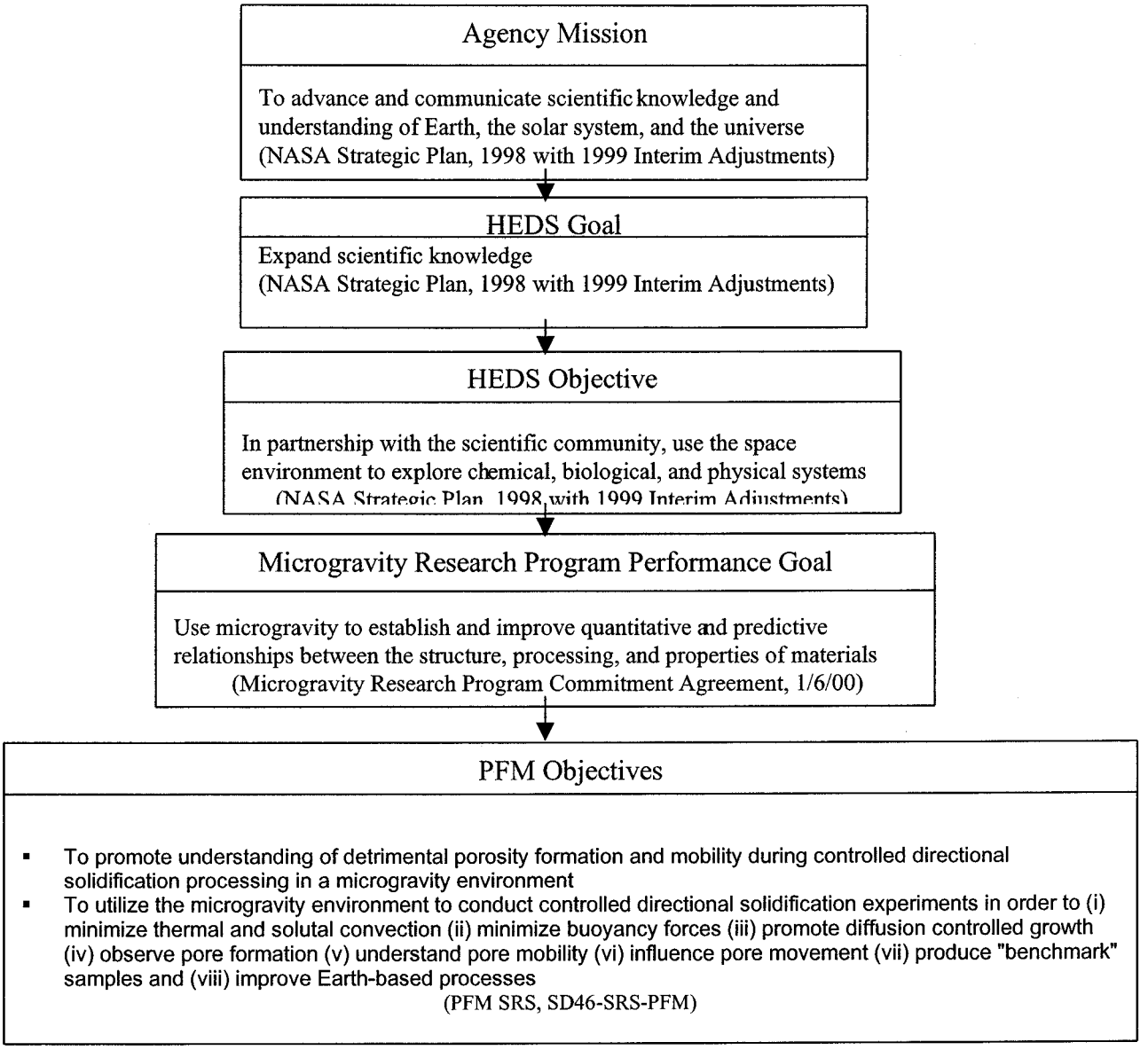

Figure 1. Agency Mission to PFM Objectives Traceability

5.0 CUSTOMER DEFINITION AND ADVOCACY

Since glovebox investigations are selected based on their benefit to related future flight investigations, the most obvious customer of the PFM investigation is the GI. The investigation is fundamental to the success of future controlled directional solidification experiments in a microgravity environment. Results of these model experiments may well be scaled to Earth-based processes. In a broader sense, customers also include academia and the general public. The GI will publish scientific analysis and results in peer-reviewed journals and present papers at science conferences as appropriate.

Customer advocacy for the GI is described in section 7.1. Customer advocacy for academia and the general public is inherent in the investigation selection process conducted by the NASA Human Exploration and Development of Space (HEDS) Enterprise Scientist. Selection of investigations are governed by HEDS goals which are defined in the NASA Strategic Plan and which serve both academia and the general public.

6.0 PROJECT AUTHORITY

The 1996 National Aeronautics and Space Administration (NASA) Glovebox Investigation Panel selected this Glovebox investigation in a peer review process and assigned it to the Glovebox Program Office at Marshall Space Flight Center (MSFC) per a memo (UG97-0337) dated December 3, 1997 from Robert C. Rhome, the director of the Microgravity Research Division (MRD).

7.0 MANAGEMENT

7.1 Organization and Responsibilities. The management of the PFM investigation has been assigned by the MRD at NASA Headquarters to the Microgravity Research Program Office (MRPO) and the Microgravity Science and Applications Department (MSAD) of the MSFC Science Directorate. MSAD will be responsible for defining specifications, schedules and budgets, establishing support agreements, acquiring and utilizing participating contractors, and executing this plan. The following roles are described based on their relevance to the daily activities for the PFM investigation.

7.1.1 Project Manager. The Project Manager (PM) assigned to this project shall be responsible for the overall Level III management activities within the project. The PM shall serve as an advocate for the GI while monitoring work being performed. The PM, the Systems Engineer (SE) and the Project Scientist (PS) shall assist the GI in developing the science requirements and overall science objectives. The PM is responsible for project wide planning, project schedule and budget. The PM also manages the contracts associated with the project.

7.1.2 Project Scientist. The PS assigned to this project shall serve as the GI's advisor at NASA and as NASA's advocate for the GI. The PS advises the GI in development of the Science Requirement Sheets (SRS). Specifically, the PS, along with the GI, is responsible for defining the investigation scope and ensuring that the science objectives of the investigation are well defined and are achievable. The PS is responsible for assisting the GI with science feasibility demonstrations and interpreting the results.

7.1.3 Systems Engineer. The SE assigned to this project shall coordinate engineering support from the Engineering and Product Line Directorates. The SE shall serve as advocate and advisor to the GI on

engineering problems and issues, in particular, those related to integration and verification of science hardware. The SE shall also serve as an advisor to the hardware developer on engineering problems and issues.

7.1.4 Glovebox Investigator. The GI is responsible for planning, directing, and successfully completing the science activities within the scope of the original proposed research as modified by the selection process. The GI shall work with the PM, SE, and PS in meeting established project milestones. The GI, with the assistance of the PM, SE, and PS, shall develop the science requirements and overall science concept required to prove the science feasibility.

7.1.5 Safety and Mission Assurance. S&MA personnel assigned to this project shall support the PM and the SE by providing specialized support in the areas of safety, reliability and quality as required to comply with the project and NASA requirements.

7.1.6 Flight Hardware Development Contractor. The flight hardware development contractor is the MSAD small flight hardware development contractor, Tec-Masters, Inc. (TMI). TMI is responsible for delivering the PFM flight hardware and software, a ground/training unit compatible with training and confidence testing requirements and associated ground support equipment.

7.1.7 Glovebox Program Office. The Glovebox Program Office is responsible for the following MSG deliverables which are dependencies for the success of the PFM investigation:

- Successful deployment of the MSG on ISS on UF-1
- Successful integration and operation of the Glovebox Integrated Microgravity Isolation Technology (g-LIMIT) on UF-1
- Generation of the investigation-specific Interface Control Document (ICD) (MSFC-ICD-3085) which contains interface agreements between PFM, g-LIMIT and the MSG
- Successfully conducting the flight-specific Investigation Integration Preliminary Design Review (IIPDR), the Investigation Integration Critical Design Review (IICDR), the Investigation Integration Readiness Review (IIRR) and the Phase III Safety activities for the integrated MSG/PFM/g-LIMIT
- Input and promotion of the data in the Payload Data Library (PDL) necessary to integrate with the ISS system and operations.

7.2 Special Boards and Committees. There are no special boards or committees for this project.

8.0 TECHNICAL REQUIREMENTS

8.1 Project Requirements. The hardware shall be designed and built to meet Dr. Grugel's science

requirements as documented in SD46-SRS-PFM and the System Requirements for Toward Understanding Pore Formation Mobility During Controlled Directional Solidification In A Microgravity Environment (PFM) for Hardware and Software, SD42-RQMT-0002 . The investigation hardware shall be designed to meet the specifications for investigations documented in the Microgravity Science Glovebox (MSG) Investigation Interface Requirements Document (MSFC-RQMT-2888), the Microgravity Science Glovebox (MSG) Payload Accommodations Handbook (MSG-RIBRE-RQ-0001) and the Microgravity Science Glovebox (MSG) Interface Control Document for Toward Understanding Pore Formation Mobility During Controlled Directional Solidification In A Microgravity Environment (PFM), (MSFC-ICD-3085). The hardware units to be developed include one flight unit and one ground/training unit.

Ground-based and flight investigation hardware, ground support equipment (GSE), and software will be based on the investigation concepts developed in the phase 3.0 Statement of Work (SOW) by the hardware developer. The articles to be developed by the contractor consist of ground/training and flight investigation packages, with a joint development responsibility with the GI for the samples/sample containment. On a case by case basis, Government Furnished Equipment (GFE) may be provided to off-set development costs. Government facilities may be utilized in any facet of the activity if deemed advantageous to the Government.

The investigation flight hardware shall be capable of operating for at least one complete mission cycle (12 - 18 month increment) including ground operations prior to flight.

8.2 System(s). To achieve the objectives of the PFM investigation, samples of SCN will be directionally solidified with video observation of the solidifying interface and/or in the fluid in front of the interface. The following hardware subsystems are required:

PFM Unique

- Thermal chamber
- Data Acquisition Pad (DAQPad)
- Process Control Module (PCM)
- Sample Assemblies
- Data Acquisition and Control Software

MSG-Provided

- MSG Ground Unit
- Ground Support Equipment (GSE)
- MSG Laptop Computer (MLC)
- g-LIMIT

Verification of the flight unit will occur initially with ground testing/characterization both individually and integrated with MSG. The MSG ground unit is needed for this testing.

8.3 System Operations Concept. The investigation hardware will be operated within the MSG utilizing MSG resources including video, power, cooling, Fire Detection and Suppression (FDS), and data handling. Also required for on-orbit processing is the g-LIMIT which provides a required quiescent acceleration environment and data/power/video connection to the MSG.

The crew will extract all PFM operating hardware from stowage and set-up the investigation within the MSG experimental volume on top of the g-LIMIT hardware that is mounted on the coldplate. The g-LIMIT hardware will have to be set-up on the MSG coldplate before PFM set-up procedures can be initiated. After initial PFM video set-up and calibration, the crew will transfer an investigation sample, contained in a sample tube and enclosed in a flight approved plastic bag, into the PFM heating chamber-processing position. After initial g-LIMIT and PFM run parameters have been selected, the crewmember and/or GI will initiate the automated processing sequence. After completion of a given sample processing run, the heater will be shut off to allow the sample to reach touch temperature. The sample will then be exchanged for the next timelined sample.

8.4 System Constraints. The system constraints are defined by the capabilities of the MSG as documented in the Microgravity Science Glovebox (MSG) Investigation Interface Requirements Document (IRD) MSFC-RQMT-2888 and the Microgravity Science Glovebox (MSG) Payload Accommodations Handbook MSG-RIBRE-RQ-0001. The system is also bounded by the capabilities of the g-LIMIT as documented in the Design Definition Document for Glovebox Integrated Microgravity Isolation Technology (g-LIMIT) Characterization Test, g-LIMIT-DOC-0001. Additionally, the system is bounded by ISS constraints (crew timelines, acquisition of signal, uplink and downlink data rates).

8.5 Ground Systems and Support. The GI will utilize MSG ground support systems for flight operations including data downlink and video.

The PFM ground/training unit will be available to training organizations with a minimum, low fidelity capability, which consists primarily of hardware and video setup and sample exchange functionality. This unit will also be used for ground-based investigations. The ground sample complement will consist of calibration and processing ampoules used to calibrate the hardware setup and emulate on-orbit profiles.

The GI will utilize the Microgravity Telescience Center (TSC), MSG ground support personnel and systems for flight operations including data downlink and commanding.

8.6 Flight Support Equipment. The GI samples will be packaged in polycarbonate tubes, bagged and then placed in a sample container box. The sample container box will be placed in a locker and stowed in the Orbiter Middeck for launch. After docking, the sample container box will be transported to the ISS. The PFM samples must be kept between 4 and 35°C.

8.7 Facilities. MSFC and other Government/private industry locations have all the necessary facilities required for the development, operation, qualification, and delivery of the PFM hardware.

8.8 Logistics. This Glovebox investigation hardware will be designed and developed by a contractor. Testing of the hardware will be conducted by the MSFC Systems Test Group and the contractor. Upon successful functional check out, MSFC will accept delivery of the hardware and

provide availability for required training at Johnson Space Center (JSC), ground testing and system characterization, etc. The hardware will be shipped to the launch site no earlier than L-5 months. Instructions for shipping and handling of the investigation hardware will be supplied by the PM to the Glovebox Program Office at least one month prior to shipping. Instructions for sample handling after flight will be documented in the MSG Investigation Requirement Sheets (IRS) for PFM on ISS/UF-1 by the Glovebox Program Office.

8.9 Mission Results Analysis and Reporting. The GI will publish scientific analysis and results in peer-reviewed journals and present papers at science conferences as appropriate.

9.0 SCHEDULE

A project master schedule for major elements of the PFM project is presented in Figure 1. Detailed schedules will be developed, maintained, and controlled by the PFM PM and Contractor.

The PFM PM will use these schedules for evaluating, managing, and reporting project performance with respect to baselined plans.

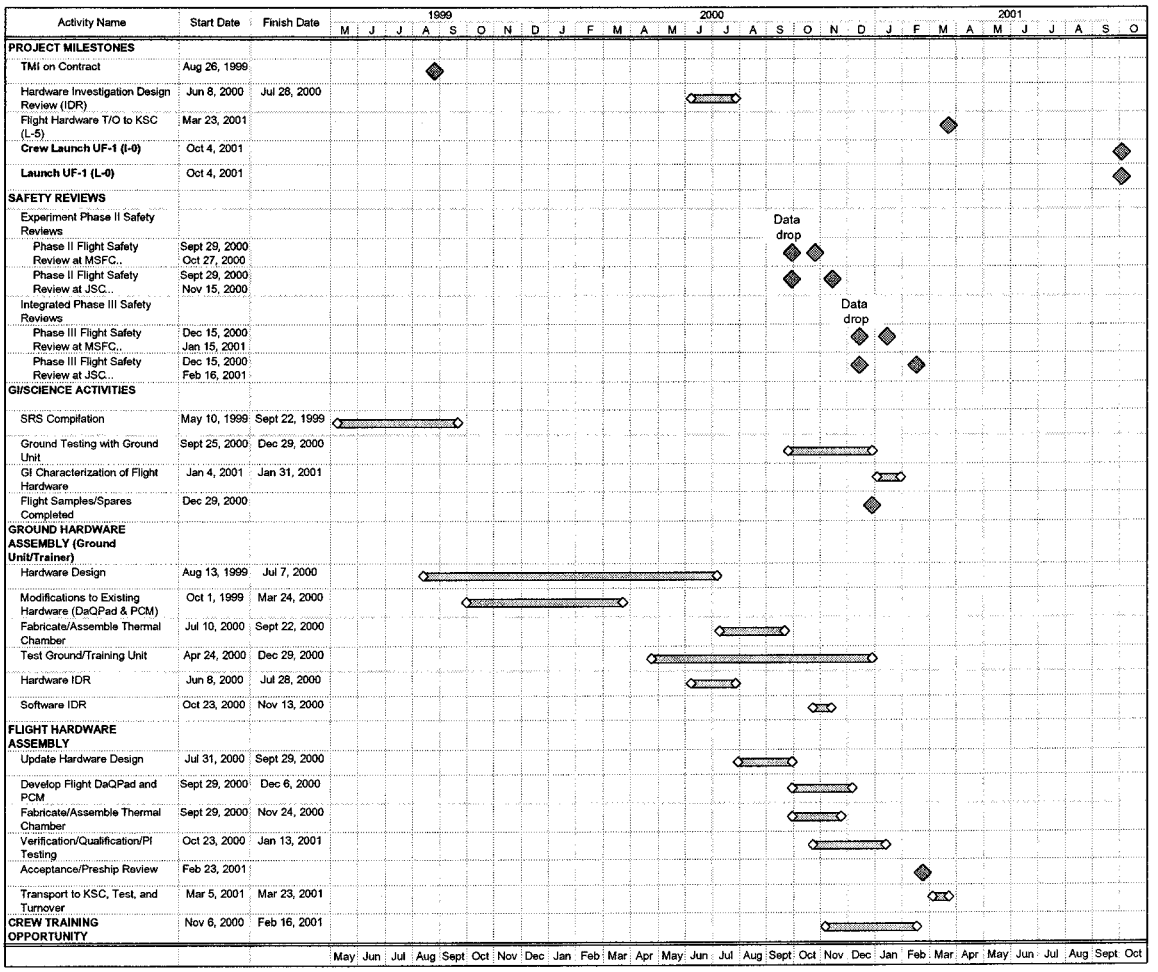

Figure 2. PFM Project Schedule

10.0 RESOURCES

Provided in Table I is the total project funding requirements by fiscal year (FY) for the PFM detailed design and development phase. The utilization of funding is planned and managed using established NASA center resources management systems.

Table I. Project Funding Requirements

	FY 1999	FY2000	FY 2001	Total
Total, $K	$ 236K	$ 50K	$252K	$538K

The investigation hardware will be designed and developed by a contractor. Civil Servant (CS) personnel are less than 5 Full Time Equivalents (FTEs). Integration is the responsibility of the MSG Integration Team.

11.0 CONTROLS

11.1 Configuration Management. The PFM Level III Configuration Control Board (CCB) will be the primary MSFC management control for the project. CCB membership will consist of the PFM PM (Chair), PS, SE, S&MA Representative, Configuration Management Secretariat and the Tec-Masters, Incorporated. (TMI) Contracting Officer's Technical Representative (COTR) at MSFC. The CCB will negotiate and control the appropriate baselines to manage the investigation requirements as shown in Figure 2.

The PFM Project Control Board (PCB) will control the schedule for the project. The membership of the PCB will be the same as the CCB.

11.2 Organization. The Science Directorate Configuration and Data Management Group (CDMG) will provide support to the PFM project. The responsibilities and authorities for the Configuration Management (CM) process are defined in MWI 8040.2. The Science Directorate CDMG will interface with the MSG project and supporting science organizations and contractors.

11.3 Phasing and Milestones. The release and submittal of documents controlled by the Level III PFM CCB will be in accordance with the Level III detailed schedule provided by the PFM PM.

11.4 Status Accounting. Status accounting for the CCB process will use the MSFC Change Processing, Tracking and Accounting System (CPTAS) as described in MSFC-MNL-1951. Status accounting for the PCB will use Program/Project Data System (PDS) as described in MWI 7120.3.

11.5 Configuration Identification. Contractor delivered hardware, equipment and software shall be identified in accordance with the contractor CMP. The document library for MSFC CCB processed documentation is the MSFC Repository. The document library for MSFC PCB processed

documentation is the PDS. The contractor shall provide a library/repository for all contractor prepared documentation maintained under contractor control. The PFM documentation tree is shown in Figure 3. Implementation of the configuration process will be in accordance with MWI 8040.2 and the Microgravity Materials Science Program Discipline Change Control Plan (DCCB) MSFC-PLAN-2997.

11.6 Interface Management. The PM, SE and the Science Directorate CDMG shall assure the identification and documentation of all interfaces between design organizations. Those technical interfaces requiring agreements between organizations shall be baselined in the PFM Level III CCB.

11.7 Data Management Plan. A separate Data Management Plan (DMP) will be written for the PFM investigation. The DMP will provide instructions to the project and the support organizations that will define how data management will be implemented for PFM. The DMP will also be used to provide planning information to the Microgravity Research Program archive system and will provide a consolidated record of the experiment data and products.

11.8 Contractor/Vendor Control. The contractor shall implement a CM and Data Management process to identify, baseline and control all project technical and programmatic information required to substantiate the contractor's performance under the contract. The contractor's project control system shall provide for control of sub-contractor and/or vendor purchase requirements to ensure that CCB baselined technical requirements (in specification or drawings) are utilized in the purchase agreements/and or sub-contracts, and that all data required to substantiate the design and the sub-contractor/vendor performance is delivered. The contractor shall ensure, by on-site evaluation, that sub-contractors/vendors have a design control process comparable to ISO 9000 in place prior to starting work on the purchase order or sub-contract or that TMI has a process in place to assure that the sub-contractor/vendors processes are covered under the TMI Quality Plan.

LEVEL A – Source Requirements

NSTS 1700.7 and ISS Addendum, MSFC-STD-2594, KHB 1700.7	PFM Science Requirements Sheets	MSG Interface Definition Document MSFC-RQMT-2888 and MSG to PFM ICD, MSFC-ICD-3085

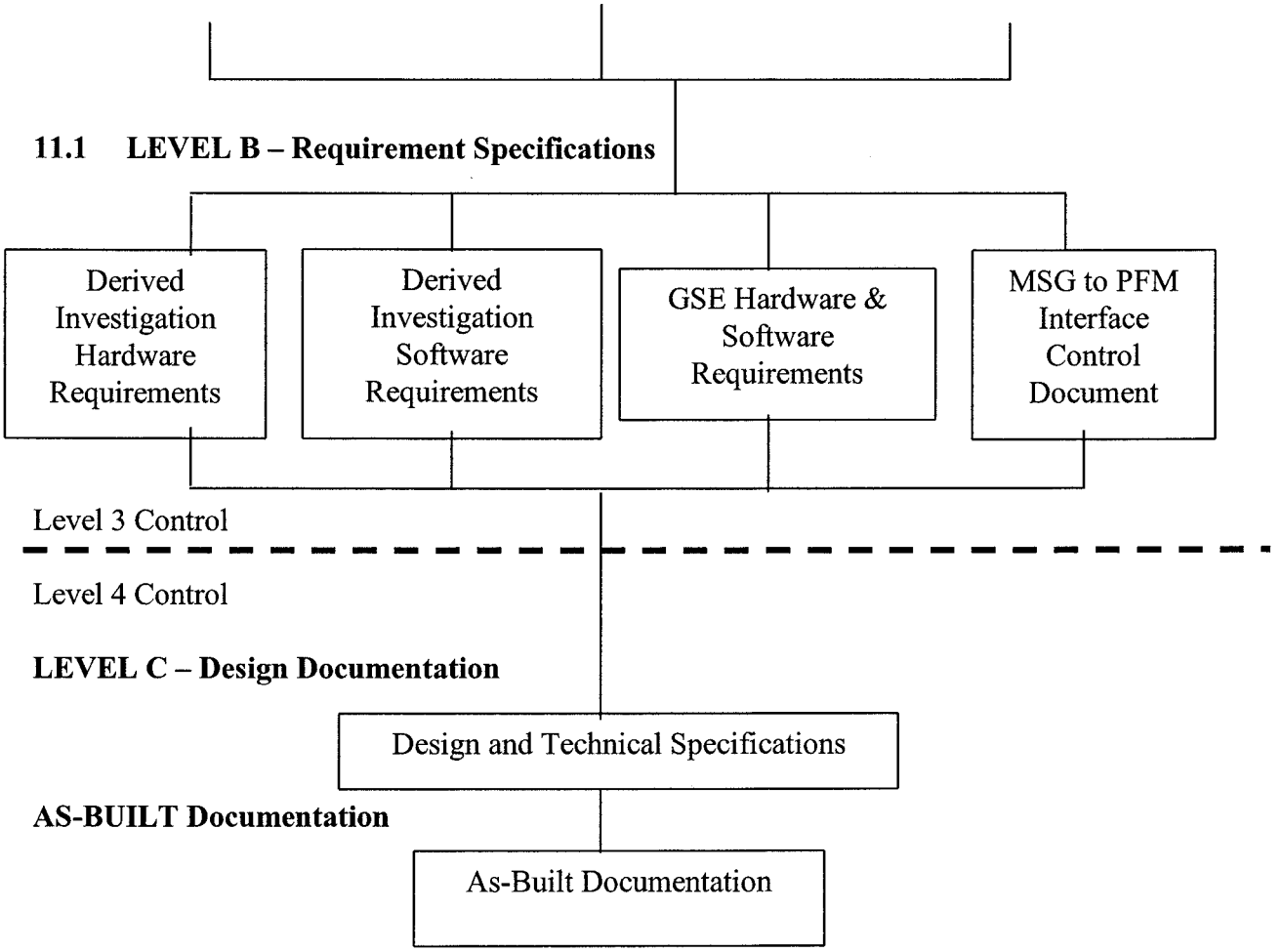

Figure 3. PFM Documentation Tree

The applicable documentation for the project is shown in Table II. TMI will have a CCB governed by the TMI CMP. The TMI CCB will control the engineering drawings and component specifications, and prepare input for other data entries as required by the integration into MSG.

Table II. Project Documentation Governed by a CCB and/or PCB

DOCUMENT	ORIGINATOR	APPROVAL	CONTROL LEVEL	CONTROL BEGINS
		LEVEL III		
PFM Project Plan	Project Manager	MSAD Manager	PFM CCB	At initial approval
MSG Investigation Interface Requirements Document (MSFC-RQMT-2888)	MSG Project Office	MSG Project Office	MSG Project Office	At initial approval
MSG ICD for PFM	MSG Project Office	MSG Project Office	MSG Project Office	At initial approval
Verification Requirements and Specification Document	Tec-Masters, Inc.	MSG Project Office	MSG Project Office	Hardware IDR
PFM Science Requirement Sheets	Glovebox Investigator	GI, PM, SE, PS	PFM CCB	At initial approval
System Requirements Document for PFM Hardware and Software	Systems Engineer	Chief, Systems Engineering Group	PFM CCB	At initial approval
MSFC Engineering Drawings and Associated Lists	Designer (ED16)	Stress, Materials, S&MA, Producibility, Checker, Designer	PFM CCB	At initial approval
Deviation/Waiver Approval Requests	Tec-Masters, Inc.	SE, PM	PFM CCB	At initial approval
System Safety/Hazard Analysis, DRD849SA-001	S&MA	PM, SE, S&MA Rep	PFM CCB	Hardware IDR
PFM Project Schedule	Project Manager	PM	PFM PCB	At initial approval
		LEVEL IV		
Configuration Management Plan, DRD 849CM-001	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	At initial approval
Structural Strength and Fatigue Analysis Reports, DRD 849DE-001	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Quality Plan, DRD 849QE-001	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	At initial approval
Thermal Design Databook, DRD 849DE-004	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Physical Properties Report	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Electrical & Interface Block Diagrams	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
TMI Engineering Drawings and Associated Lists, DRD 849CM-003	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Materials and Processes Identification and Usage List (MIUL), DRD 849MP-001	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Material Usage Agreements (MUAs), DRD 849MP-002	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR
Software Operator's Manual	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Software Delivery
Software Design Description	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Software IDR
Software Development Plan	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Software IDR

Software Requirements Specification	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Software IDR
Equipment Log Book, DRD 849RM-002	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	AR
Verification Reports, DRD 849VR-001	Tec-Masters, Inc.	TMI LEVEL IV CCB	TMI LEVEL IV CCB	Hardware IDR

12.0 IMPLEMENTATION APPROACH/ACQUISITION SUMMARY

The project hardware shall be procured by a Delivery Order to NAS8-98098. In addition, the project shall use, to the maximum extent possible, hardware available in the MSFC inventory to defray costs. The design and development of the hardware and associated documentation shall be controlled by the PCB as delineated in section 11.0.

The MSFC Safety & Mission Assurance (S&MA) is responsible for the PFM Flight Safety Compliance Data Package (SCDP) and the Ground SCDP. The MSFC MSAD Systems Engineering Group is responsible for the System Requirements Document for PFM Hardware and Software, SD42-RQMT-0002. The MSFC Engineering Directorate will be called upon to support reviews. The MSFC MSAD Systems Test Group will support test activities. All MSFC manpower will be acquired via the Collaborative Work Commitment (CWC) process. Dr. Grugel's research effort is funded via in-house through the MSAD.

13.0 PROJECT DEPENDENCIES

The PFM investigation will be performed in the ISS MSG. Power distribution, cooling, video and data interfaces will be provided to the PFM by ISS MSG. The PFM science requires the g-LIMIT hardware which provides the required quiescent acceleration environment.

14.0 AGREEMENTS

A Microgravity Science Glovebox (MSG) Interface Control Document for Toward Understanding Pore Formation and Mobility During Controlled Directional Solidification in a Microgravity Environment (PFM), MSFC-ICD-3085, has been compiled between the MSG Integration Team and the PFM project.

15.0 PERFORMANCE ASSURANCE

Performance assurance requirements for PFM are applicable for flight hardware only. Development hardware will be developed using standard good lab practices, such as keeping laboratory notebooks. There will be no design control (baselined drawings, configuration management, design reviews, etc.), no procurement quality requirements, no quality inspections, and no quality assurance during testing required for development hardware. Due to this approach, no attempt will be made to upgrade development hardware to flight hardware.

15.1 Reliability and Maintainability. The PFM reliability requirements are as specified in this document, SD42-RQMT-002 and MSFC-RQMT-2888 and constitute the PFM Reliability Plan for flight hardware. The SE and TMI are required to screen Acute Launch Emergency Restraint Tips (ALERTS) and process them in accordance with the contract and MWI 1280.5. ALERTS status will be reported and reviewed at the Acceptance Review/Preship Review (AR/PSR) and Flight Readiness Review (FRR).

PFM hardware will be designed to operate for at least one complete mission cycle (12-18 month increment) including ground operations prior to flight.

15.2 Quality Assurance. The PFM Quality Assurance (QA) requirements are as specified in this document and constitute the PFM QA Plan for flight hardware. The PFM Investigation will comply with ANSI/ASQC Q9001-1994 and associated MSFC quality management system (QMS) documentation. The PFM flight subsystem hardware shall be built and assembled by TMI or their subcontractor in accordance with the TMI Quality Plan, which shall be compliant with the requirements of ANSI/ASQC Q9001-1994 and other requirements as may be imposed by the contract. All PFM activities performed at MSFC will follow the MSFC QMS.

15.2.1 Design Reviews. Reviews are described in section 21.0. Review Item Discrepancies (RIDS) are processed and tracked as described in each design review plan. Each review will have an associated review plan.

15.2.2 Purchasing. Flight hardware purchased through the TMI contract will comply with the TMI Quality Plan requirements for purchasing and the TMI contract. Any flight hardware purchasing performed at MSFC for the PFM project will follow the MSFC QMS system requirements for procurement. Commercial off-the-shelf (COTS) parts are acceptable. Electrical, Electronic and Electromechanical (EEE) parts will be procured in accordance with NPD 8730.2, NASA Parts Policy. Fasteners will be procured in accordance with MSFC-STD-2594, Threaded Fastener Management and Control Practices.

15.2.3 Receiving Inspection and Test. All flight and ground hardware will have receiving inspections and testing by TMI which complies with the TMI Quality Plan requirements for receiving inspection and testing and the TMI contract. Any hardware received for the PFM project at MSFC will follow the MSFC QMS system requirements for receiving inspection and testing.

15.2.4 In-Process Inspection and Test. In process inspections and testing for flight hardware at the contractor facility will be performed per the TMI Quality Plan requirements and the TMI contract. The contractor will perform inspection and testing, however, MSFC Quality will be required during any system-level or subsystem-level activities at MSFC involving the flight hardware.

15.2.5 Final Inspection and Test. An Acceptance Data Package (ADP) containing, as a minimum, the following: Material Usage Agreements (MUA), Material Item Usage List (MIUL), electrical schematics, design/as built drawings, analysis reports, parts lists, discrepancy records, physical properties reports, and component and system level testing results shall accompany the hardware upon receipt at MSFC. A signed Certificate of Compliance (COC) from the vendor should certify compliance

with verification and functional requirements performed by the vendor. An inspection and functional test of the hardware will be performed prior to MSFC acceptance of the hardware/software from TMI.

15.2.6 Materials and Processes Control. All hardware components will be governed by the MIUL and MUA documents to meet off-gassing, flammability and corrosion requirements. Inspection Record (IR) tags will be utilized at the subsystem and assembly complete level and not at the component level.

15.2.7 Verification, Certification, and Required Data. TMI is required to supply a Verification Requirements and Specification Document (VRSD) and Verification Compliance Document and Verification Reports as defined in the contract. The VRSD will be developed by the hardware developer to assure that the flight hardware meets the specified design, interface, and safety requirements in addition to meeting the functional requirements documented in SD42-RQMT-002 and MSFC-RQMT-2888. Requirements will be verified by inspection, analysis, and/or testing by the MSFC Systems Test Group and TMI per Sections 4.0 and 5.0 of the MSG IIRD, MSFC-RQMT-2888. Verification requirements and status will be reported and reviewed at the Safety Reviews, Acceptance Review/Preship Review (AR/PSR), and the FRR. All science requirements and system requirements will be assessed on a pass/fail basis as defined in the VRSD.

15.2.8 Shipping, Inspection and Verification. Prior to shipping the flight hardware to the launch site, acceptability of the hardware will be assessed at an AR/PSR as described in section 21.0. After shipment to the launch site, the hardware will be checked out prior to turnover to Kennedy Space Center (KSC) integration.

Prior to shipping the ground/training unit to the training site, acceptability of the hardware will be assessed at a ground/training unit preship test review. All hardware shipments will be in compliance with MPG 6410.1, Handling, Storage, Packaging, Preservation, and Delivery (H.S.P.P.& D.)

15.2.9 Contamination Allowance and Control. Contamination control will be part of the PFM hardware design with requirements specified per MSFC-RQMT-2888.

15.2.10 Quality Plan Configuration Management, Review and Approval. The TMI Quality Plan was submitted to MSFC for review of acceptability when the contract was issued. Whenever any revisions to the plan have been made, the plan must be resubmitted to MSFC for review. The MSFC Quality Plan requirements in this Project Plan must be baselined by the PFM Level III CCB, including review and concurrence from S&MA. Since the Quality Plan requirements reside in the Project Plan, the approval signature page must have an S&MA signature.

15.2.11 Software Assurance. Software will be developed in accordance with the contractor's internal procedures, and verified during functional testing at MSFC and with the MSG flight unit at KSC. Any changes to the software after MSFC acceptance must be documented by the contractor and approved by the CCB. No independent software verification and validation will be performed due to the system software testing and checkout required and the "low cost" classification of the project.

15.2.12 Nonconformance/Material Review Board Processing. TMI shall process non-conformances per the TMI Quality Plan. TMI shall submit non-conformances and their closure rationale as a part of

the AR ADP. Closures recommending "use as is" or "repair" shall be brought to a TMI Material Review Board (MRB) for approval and MSFC S&MA participation shall be required when the recommended disposition is "use as is" or "repair".

15.2.13 Quality Plan Quality Records Requirements. Since the Quality Plan is incorporated into this Project Plan, it will be considered a part of the Project Plan quality record.

16.0 RISK MANAGEMENT

The risk management strategy for PFM is to identify, analyze, plan, track, control, communicate and document critical areas and risk events, both technical and non-technical, and take necessary action to manage them to prevent serious cost, schedule or performance impacts. The Materials Science Program Office of the MSAD at MSFC acknowledges and accepts the high risk associated with a Glovebox investigation. Risk information will be included in all program reviews and, as new information becomes available, the PFM team will conduct additional reviews to reassess the identified risks and to ascertain if new risks exist. The goal is to continuously monitor the program for areas that may add to project risk and to provide mitigation in a timely manner. PFM is a Type III project as defined in MWI 7120.6, Program/Project Risk Management, due to the low complexity, low cost classification of the project. PFM/SUBSA falls under the Project Management Council threshold and is a simple subrack payload.

A Risk Management Database Guide for PFM has been written that provides a tool for the PFM project explaining the methodologies and processes to be used for risk identification, assessment, analysis and mitigation. A database has been constructed for tracking risks identified by PFM team members which provides criteria for categorizing or ranking risk according to probability and consequences and provides the documentation requirements for risk management products and actions.

17.0 ENVIRONMENTAL IMPACT

Cleaning agents and sample materials utilized in the development of this hardware are under control by the developer and/or MSFC team using standard control procedures. Sample containment hazard control is approved by MSFC S&MA for ground and flight processing.

18.0 SAFETY

18.1 General. PFM safety requirements are applicable to flight hardware and software and associated GSE. S&MA is responsible for development of the SCDPs with input from the GI and TMI. S&MA will participate in JSC, KSC and MSFC Payload Safety Readiness Review Board (PSRRB) flight safety reviews through the Glovebox Program Office. The safety review schedule is defined to PFM by the Glovebox Program Office. PFM stand-alone Phase I/II and Phase III Safety Reviews will be held in a timely manner to support the MSG Integrated Phase III Safety Review. KSC ground safety reviews will also be conducted to ensure compliance with KSC safety requirements.

18.2 Industrial Safety. For on-site activities, the PFM Industrial Safety Program will be the MPG 8715.1, Marshall Safety, Health, and Environmental (SHE) Program for MSFC on-site operations. Off-site activity industrial safety controls are under the auspices of pertinent facility standards at those locations.

18.3 Ground Safety. The PFM project will comply with the safety requirements in KHB 1700.7. A Ground SCDP will be developed by S&MA with inputs from the GI, PM, SE, PS and TMI in accordance with the data requirements contained in KHB 1700.7. The PFM project will participate in KSC phased safety reviews as required by NSTS 13830.

18.4 Flight Safety. The PFM project will comply with the safety requirements identified in NSTS 1700.7 and Addendum. A Flight SCDP will be developed by S&MA in accordance with the data requirements contained in NSTS 13830, Implementation Procedure for NSTS Payloads Systems Safety Requirements. The PFM project will participate in JSC phased safety reviews as required by NSTS 13830, as well as the MSFC PSRRB process. Responsibility for compiling the Integrated MSG SCDP and submitting it to JSC lies within the Glovebox Program Office.

19.0 TECHNOLOGY ASSESSMENT

To optimize cost, the PFM project is utilizing COTS hardware where feasible.

20.0 COMMERCIALIZATION

There are no near term opportunities for commercialization identified at this time. The PFM project will continue to interface with the microgravity technologist to promote further commercial opportunities as they are identified.

21.0 REVIEWS

The PFM project will conduct a hardware Investigation Design Review (IDR) at the completion of the ground hardware/training unit development. The PFM PM/SE will send a formal request that requests support for the design review to the appropriate groups in the MSFC Directorates. A design review plan will be written and a fully independent review team will be utilized for the design review. Findings will be documented on RID forms and the whole process will culminate in a Preboard/Board with minutes documenting all issues and actions assigned by the Preboard/Board. An independent set of experienced personnel will participate in the reviews. A software IDR will be conducted at the completion of the ground software in the same fashion as the hardware IDR. A hardware AR/PSR and a FRR will also be held. An AR/PSR Plan and FRR Plan will be written by the PFM Project Office in a timely manner before these reviews. These plans will specify pre-board and board membership.

Since PFM is a Space Shuttle Payload, Safety Reviews will be conducted in accordance with the requirements of NSTS 13830 and NSTS 1700.7 and Addendum. MSFC will be responsible for providing the appropriate safety information to the Glovebox Flight Program Office in support of the Flight/Ground Safety Reviews and MSFC PSRRB reviews. Informal Test Readiness Reviews (TRRs) will be held as needed for system testing. Prior to acceptance of the PFM and associated GSE from TMI, the AR/PSR will be conducted to ensure all necessary design, fabrication, assembly, and verification activities have been satisfactorily completed.

The PFM project will participate in the Investigation Integration Team (IIT) integrated MSG reviews per the Microgravity Science Glovebox (MSG) Investigation Integration Plan, MSFC-PLAN-3052.

22.0 TAILORING

Considering Glovebox project characteristics (low cost, high risk, and augmentation of flight or ground investigation), this document has been specifically tailored to meet the needs of the PFM project. The QA Plan, Risk Management Plan, and CMP are included in this document.

23.0 QUALITY RECORDS

The Quality Records project identifier for the PFM Project is given, in Appendix A of SD40-OWI-001. The PM Quality Records for the PFM Investigation will include:

- Incoming and Outgoing Correspondence deemed critical for project success.
- Project Plan
- Science Requirement Sheets (SRS)
- Investigation Proposal
- Investigation Selection Results
- GI Final Report
- Contract Documentation
- Review Documentation
- Safety Data Packages (flight and ground)
- Risk Documentation
- Problem Reports
- Deviations and Waivers

The quality records for the PFM CM process is the documentation maintained in the program control files such as change requests, directives and specification change notices. Maintaining these quality records is the responsibility of the PFM Secretariat and the files will be maintained by a CM support contractor.

The quality record for the PFM PCB process is the electronic files contained in PDS as described in MWI 7120.3 which includes, but is not limited to, the master project list, documents, implementation instructions and change evaluations.

Quality Records for other supporting organizations will be maintained in accordance with their Organizational Work Instructions (OWIs).